United States Patent [19]

Harris

[11] **3,772,620**

[45] **Nov. 13, 1973**

[54] **CONDITION CONTROL DEVICE AND SYSTEM**

[75] Inventor: **John L. Harris,** Clearwater, Fla.

[73] Assignee: **Deltrol Corp.,** Bellwood, Ill.

[22] Filed: **Aug. 23, 1972**

[21] Appl. No.: **283,110**

Related U.S. Application Data

[62] Division of Ser. No. 133,077, April 12, 1971, Pat. No. 3,716,720.

[52] **U.S. Cl.** **335/63,** 335/190

[51] **Int. Cl.** **H01h 7/14**

[58] **Field of Search** 335/63, 64, 73, 190, 335/189, 191, 255, 258

[56] **References Cited**

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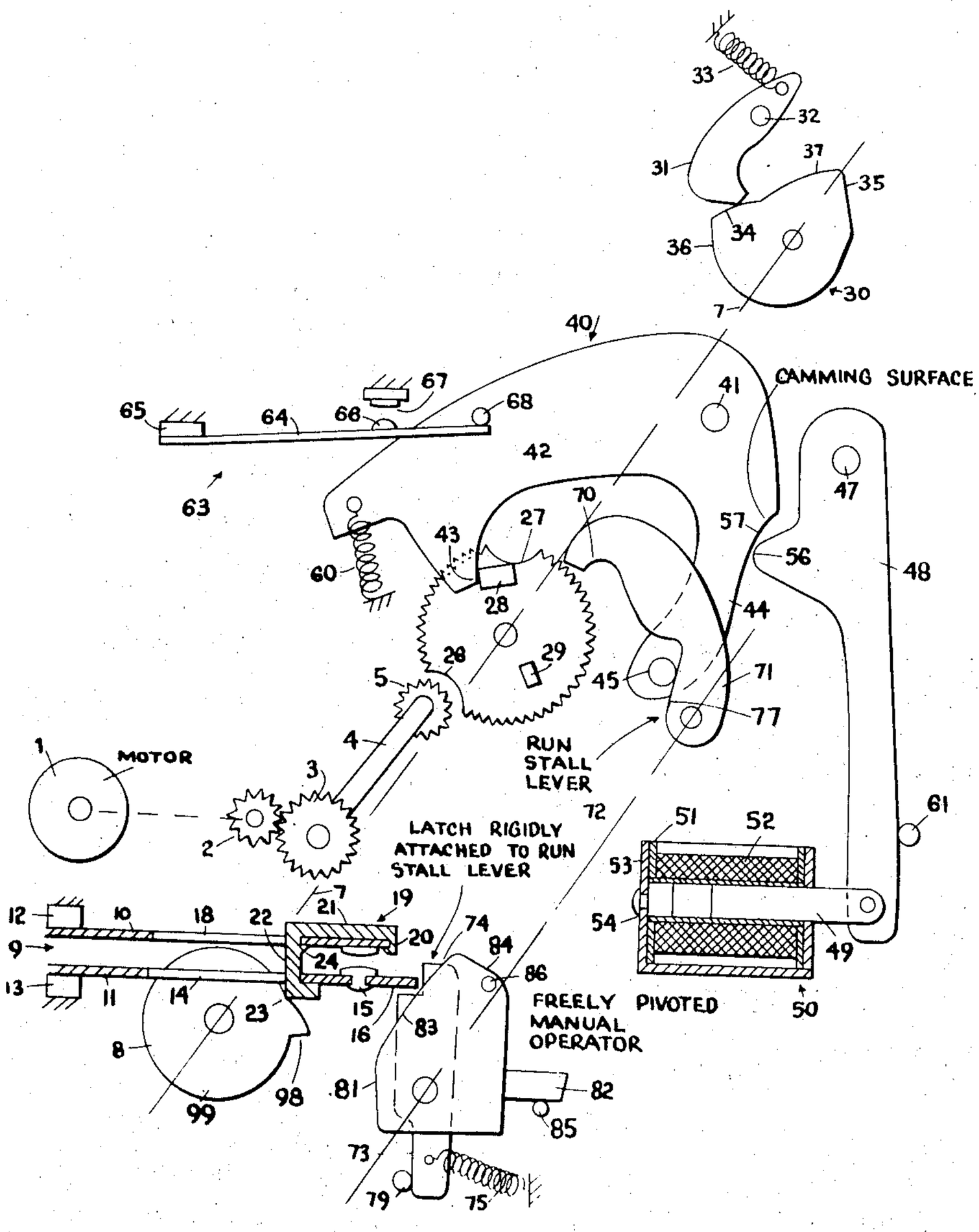
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Primary Examiner—Harold Broome
Attorney—John L. Harris

[57] **ABSTRACT**

A solenoid operated device includes a camming linkage between the solenoid plunger and a member actuated thereby. This camming linkage is characterized to provide a reduced load on the plunger at its starting position and to increase the load as the plunger pulls in.

4 Claims, 3 Drawing Figures



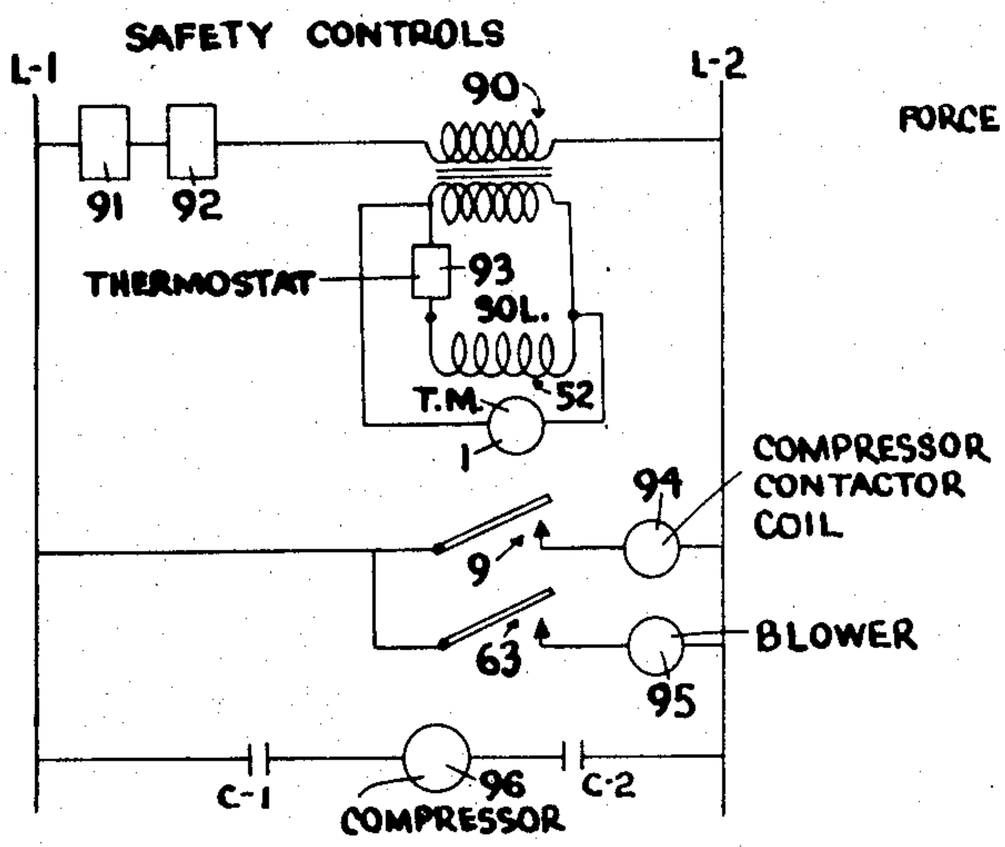


Fig. 2

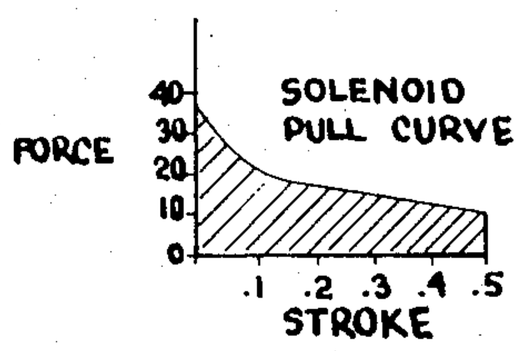
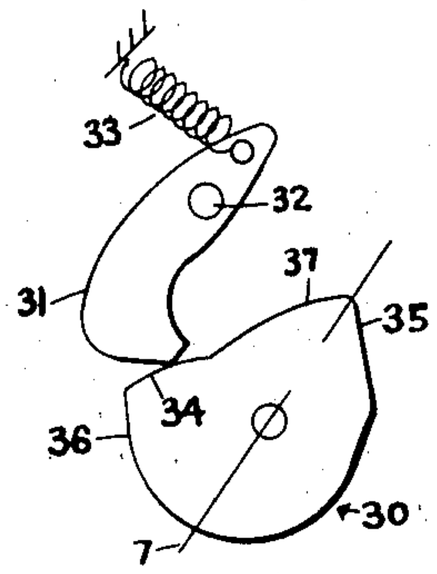


Fig. 3



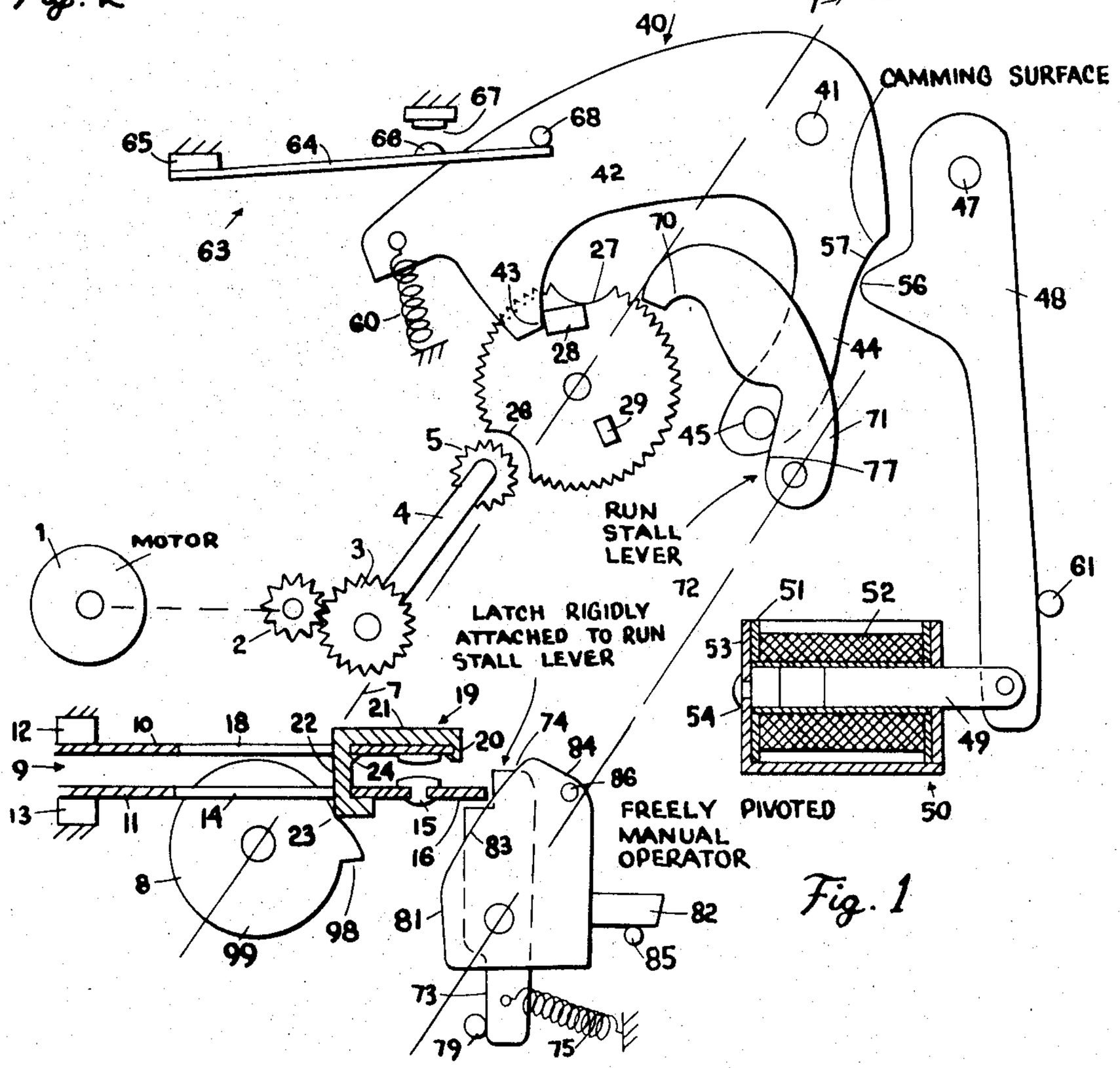


Fig. 1

CONDITION CONTROL DEVICE AND SYSTEM

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a division of application Ser. No. 133,077, filed Apr. 12, 1971, now U.S. Pat. No. 3,716,720.

BACKGROUND OF INVENTION

This invention relates to automatic controls and more particularly to time delay devices and control systems for protecting electric motors such as refrigeration system compressors.

In the air conditioning and refrigeration industry it has become common to install a time delay system between the compressor contactor and the thermostat and protective controls. The purpose is to prevent damage to the compressor by short cycling due to the safety controls responding to excessive high or low pressures caused by a malfunctioning system. Such time delays also protect against frequency stops and starts by thermostat jiggling, and insure a delay between stopping and restarting long enough to allow the pressures in the system to equalize so the compressor starts in an unloaded condition. Timers have also been used in compressor control systems for shunting out the high and low pressure controls for a short period of time when the compressor first starts. This is done to give time for surges in the system to settle down. This avoids false stops of the compressor and thus reduces the number of starts required.

Prior to applicant's invention, the delay mechanism required a timer and at least one relay. Also a separate timer was required to give the surge settling period, and the system required a considerable amount of electrical connections between the various components.

One problem encountered with prior art systems is testing of the system. The usual time cycle is on the order of five minutes. In the factory or on service calls, this requires waste of considerable time. A manual override is needed and this must be one that can't be left in an unsafe condition.

Another problem is the wide variation of voltages encountered. Some areas have 208 volt service while others have 240 volt service. These voltages can vary 10 percent either way. It is desirable from an inventory standpoint to have a single unit usable on both voltages. This requires satisfactory performance over a range from 187 to 264 volts. Where a control includes a solenoid, this voltage range gets into a problem of underpower at the low voltage and overheating at the high voltage, requiring an oversize solenoid for the low voltage and special insulation for the high voltage.

BRIEF SUMMARY OF INVENTION

The present invention provides a single component that may be wired between the thermostat and compressor contactor. This component includes a switch for the contactor which is actuated in part by an electric timing mechanism and a solenoid controlled by the room thermostat. When the thermostat calls for cooling it energizes the solenoid. This actuates a spring biased lever carrying a standby stop which releases a stalling lug on the timer gear. This allows a starter cam follower to advance the gear into engagement with a pinion which is rotated constantly by the timer motor.

The timer runs for 15 seconds and closes the contactor switch which is now held closed by a latch.

The switch consists of two blades lifted by a single cam follower with contacts disengaged. The blades are then released by the timer cam and the latch holds one blade up to maintain the contacts engaged.

The timer continues to run for another 15 seconds during which time the stalling lug on the gear blocks out the solenoid lever, keeping this lever from being actuated by dropping out of the solenoid. This provides a minimum run period allowing surges to settle down. After approximately 90 seconds the timer gear disengages from its drive pinion and the timer gear is stalled by a run stop.

When the thermostat is satisfied, it drops out the solenoid which: (1) Releases the switch latch opening the switch to stop the compressor: (2) Releases the run stop allowing the timer gear to advance into engagement with the drive pinion; and (3) Returns the standby stop into stalling position. The timer then runs approximately five minutes and returns to the standby position where the standby stop stalls it with the gears disengaged.

The solenoid operates the stops and latch through a compound lever mechanism providing a long stroke for the solenoid. This compound leverage also includes a camming action compensating for the non-linear force-stroke characteristic of the solenoid.

A manually operated lever is mounted on the latch pivot and has a camming surface lifting the inner switch blade to close the switch contacts and lift the switch beyond the reach of the cam. When the solenoid drops out to release the latch it also releases the manual lever.

One object of the invention is to provide a simple compact time delay mechanism in which the controlling functions are achieved mechanically with a minimum amount of components and electrical connections.

A further object is to provide a small compact unit operable over a wide range of line voltages.

Another object of the invention is to provide a manual override of the time delay mechanism which is simple in construction and which is self releasing so that no danger is involved in forgetting to release the override.

A further object is to provide an improved switching mechanism in which a cam closes the switch contacts under the control of a latch.

Another object is to increase the usable capacity of an electro-magnet thus making it possible to use a smaller and less expensive unit for a given function.

Other objects will appear from the following detailed description and appended claims.

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 is a schematic illustration of a combination timer and solenoid operated control mechanism embodying the invention.

FIG. 2 is a schematic wiring diagram of a typical air-conditioning system embodying the invention.

FIG. 3 is a typical solenoid stroke-force curve.

DETAILED DESCRIPTION OF INVENTION

Referring to FIG. 1, reference character 1 indicates an electric timing motor which drives a pinion 2 in turn driving gear 3 carried by shaft 4 which also carries a pinion 5. The pinion 5 drives the main timing gear 6 carried by the main shaft 7 which also carries a cam 8.

The cam 8 operates a switch generally indicated as 9 consisting of switch blades 10 and 11 which are anchored at their left hand ends as at 12 and 13. The switch blade 11 is provided with a slot 14 and straddles the cam 8. The switch blade 11 carries a contact 15 and is provided with an extension 16. The switch blade 10 is formed with a slot 18 and carries a molded plastic cam follower 19. This follower includes a downwardly extending hook portion 20 which extends around the right hand end of blade 18 and bears on the bottom of this blade. The cam follower 19 also includes a horizontal portion 21 extending parallel with the blade along the top thereof and merging with a downwardly extending portion 22. The downward extension 22 passes through the slot 14 in switch blade 11 and then extends to the right along the bottom of blade 11 for lifting the same. As shown in the drawing, the extension 22 passes freely through the slot 14 in the blade and includes the corner 23 which serves a a cam follower surface riding the periphery of the cam 8. The cam follower 19 also includes an inclined supporting surface 24 extending under the lower edge of blade 10 adjacent the right hand edge of the slot 18. The cam follower 19 is molded of a suitable flexible material allowing it to be snapped into place on the switch blade 10 without any other fastening means.

The gear 6 is of the mutilated type having two portions 26 and 27 in which the gear teeth are omitted. The gear 6 also includes a standby stop lug 28 and a run stop lug 29 which extend from the front face of the gear as seen in the drawing. The cam shaft 7 also carries a starter cam 30 which cooperates with a starter cam follower 31 which is pivoted at 32 and is biased against the cam by a spring 33. This starter cam is formed with two sloping drop-off portions 34 and 35. The cam is also formed with two rise portions 36 and 37.

A solenoid operated lever 40 is pivoted at 41 and has a leg 42 which extends to the left of pivot 41 and downwardly into the path of the stalling lug 28.

The lever also has a downwardly extending leg 44 carrying an abutment 45 which extends forwardly as seen in the drawing.

Mounted on a pivot 47 which is spaced from pivot 41 is a second lever 48. This lever extends downwardly and is attached to the plunger 49 of a solenoid or electro-magnet generally indicated as 50. This solenoid includes a bobbin 51 supporting a coil 52 and fitting inside a "C" frame 53. The plunger 49 is of magnetic material and extends into the center core of the bobbin. A suitable backstop 54 is attached to the fram 53. The backstop, frame and plunger provide a magnetic path serving to pull the plunger 49 to the left when the coil 52 is energized. This energization of the solenoid coil 52 serves to cause rotation of the lever 48 in a clockwise direction about its pivot 47.

The lever 48 is formed with a driving surface 56 which bears against a driven surface 57 formed on the edge of lever 40. It will be apparent that upon energization of the coil 52 and rotation of the lever 48 clockwise, the engagement of surfaces 56 and 57 will cause clockwise rotation of the lever 40 about its pivot 41.

The lever 40 is a power take-off member from the solenoid and is provided with a biasing spring 60 tending to rotate this lever counterclockwise about pivot 41. This maintains the driven surface 57 of lever 40 in engagement with the driving surface 56 of lever 48. Thus, when the solenoid coil 52 is deenergized, spring 60 is free to rotate lever 40 counterclockwise which in turn rotates lever 48 counterclockwise toward engagement with a stop 61.

The lever 40 also actuates a switch generally indicated as 63. This switch includes a switch blade 64 which is anchored at its left hand end as at 65 and carries a contact 66 cooperating with a stationary contact 67. The switch blade 64 extends alongside the lever 40 and is actuated by a pin 68 carried on this lever. The switch blade 64 is biased upwardly tending to cause contact 66 to engage contact 67. However, when the solenoid 50 is deenergized and the lever 40 is rotated to its counter clockwise limit of rotation by the biasing spring 60, the pin 68 on the lever pulls the switch blade 64 down for disengaging contact 66. When the solenoid is energized, it rotates lever 40 clockwise, thus raising the pin 68 and allowing contact 66 to engage contact 67.

A run stop surface 70 is carried on a run stop lever 71 which is pivoted on a shaft diagrammatically illustrated as 72. The shaft 72 also carries a latch 73 having a latching surface 74. The latch 73 is provided with a spring 75 tending to rotate this latch into latching engagement with the extension 16 of switch blade 11. The run stall lever 71 and the latch 73 are shown as two separate parts for illustrative purposes only. Preferably, these parts are molded in one piece. The run stall lever 70 is formed with a driven surface 77 adjacent the pin 45 carried on lever 40. When the solenoid 50 is deenergized and lever 40 is in the position shown, the pin 45 has engaged the driven surface of lever 70 causing it to assume the position shown in which the stalling surface 70 is out of the path of the abutment 29 on the gear 6. This motion of lever 71 has also moved the latch 73 to releasing position in which the contacts of switch 9 are open. This same motion of the lever 71 has also caused the lower leg of the latch 73 to engage a stop 79. The pin 45 engaging driven surface of lever 71 and the engagement of the latch 73 with the stop 79 serves as a stop for limiting the counterclockwise rotation of lever 40. It should be noted that the standby abutment 28 on the gear 6 is at a greater distance from center than the run abutment 29. It is important that the counterclockwise limit of rotation of lever 40 be limited so that it never gets in the path of the run abutment 29 on the gear.

Mounted loosely on the shaft 72 supporting the run stall lever 71 and the latch 73 is a manually operated lever 81. This lever includes a handle portion 82 which should extend outside of the enclosure (not shown) in which the mechanism is located. The manual lever 81 is mounted beside the latch 73 and under the extension 16 of switch blade 11. This latch includes a camming surface 83 and a holding surface 84. This holding surface 84 is preferably defined by a radius centered on the center of shaft 72. A stop 85 limits rotation of the lever 81 in the clockwise direction.

FIG. 2 shows schematically the wiring diagram for a typical air-conditioning system embodying the invention. The primary of a transformer 90 is connected across line wires L1 and L2 in series with the safety controls 91 and 92. These safety controls may include a high pressure cut-out, a low pressure cut-out, and overload cut-out, etc. The secondary of the transformer 90 supplies current to the coil 52 of the timer solenoid in series with a room thermostat 93. The timer motor 1 is wired across the transformer secondary so

as to run continuously as long as power is supplied to the transformer **90.** While it is preferable to employ a low voltage thermostat, if desired, a line voltage thermostat may be used. In such event, the transformer **90** may be omitted and line voltage power from the safety controls applied directly to the timer motor and solenoid. This, of course, would require different windings for the timer motor and solenoid.

Switches **9** and **63** are connected in parallel to the line wire **L1.** Switch **9** controls the power to the compressor contactor coil **94** while switch **63** controls power to the blower motor **95.** The compressor contactor coil controls contacts **C1** and **C2** controlling power to the compressor motor **96.**

OPERATION

With the parts in the position shown, the control is in the standby position awaiting a call for cooling by the thermostat **93. Switch 9** is open thus deenergizing the compressor contactor coil causing switches **C1** and **C2** to be open and the compressor therefore deenergized. Switch **63** is also open so that the blower **95** is deenergized. Assuming the safety controls **91** and **92** are closed power is supplied to the transformer **90** and the timer motor **1** is running. However, the gear **6** is now positioned with the toothless portion **26** adjacent the pinion **5,** thus the motor **1** in an unloaded condition. At this time the starter cam follower **31** is pressing against the downward sloping portion **34** of the starter cam **30.** This is applying a torque to the cam shaft or timing means tending to rotate it in a counterclockwise direction. This motion, however is restrained by the standby stalling surface **43** being in the path of the stalling lug **28** on gear **6.** The lever **40** is in stalling position due to the solenoid **50** now being deenergized.

When the thermostat or external condition responsive means **93** calls for cooling, it energizes the solenoid coil **52** pulling the plunger **49** to the right, thus causing lever **48** to rotate lever **40** clockwise through the camming surface **57** of this lever. This movement releases the stalling means or surface **43** from abutment **28** of the driven gear **6.** The starter cam follower **31** acting on surface **34** is now free to advance the timing means **6–8** in a counterclockwise direction bringing the teeth of gear **6** into mesh with the pinion **5.** The gear **6** and cam **8** are now driven by the motor **1** in a counterclockwise direction. The cam follower **19** carried by switch blade **10** is now raised by the cam **8** thus lifting switch blades **10** and **11** with the contacts separated. As the cam follower approaches the top of its stroke the extension **16** on switch blade **11** clears the latching surface **74** of latch **73.** At this time the abutment **45** carried by lever **40** is to the left and clear of surface **77** of the run stall lever **71.** The run stall lever **71** and latch **73** are therefore free to be moved in a counterclockwise direction by spring **75.** The latching surface **74** of latch **73** therefore becomes positioned beneath the extension **16** of the switch blade **11.** Also the stalling surface **70** moves into the path of the run stall lug **29** on gear **6.** When the cam follower **19** is dropped by the lobe **98** of cam **8,** both switch blades **10** and **11** are free to drop. The extension **16** of blade **11** now is supported by the latching surface **74** of latch **73.** The contacts now engage before the cam follower **19** drops to the lower surface **99** of the cam **8.** Preferrably the cam speed and configuration is designed so that an interval of approximately 15 seconds elapses between the time the solenoid is first energized and the switch **9** closes. As the blower switch **63** closed immediately when the solenoid was energized, this gives a period of time for the blower to remove hot air from the condenser before the compressor is started.

After switch **9** closes for starting the compressor, the gear **6** continues to be driven by the pinion **5** and the starter cam follower **31** rides up the sloping surface **37** on the cam **30** thus storing power in the spring **33.** Approximately 90 seconds after switch **9** closes, the cam follower **31** starts down the sloping portion **35** of cam **30.** At approximately the same time the toothless section **27** of gear **6** approaches the pinion **5** thus releasing the gear from pinion **5.** The cam shaft assembly is now driven forward by the cam follower **31,** bringing the run abutment **29** on gear **6** into engagement with the run stop **70** on lever **71.** The cam shaft assembly is now stopped with the toothless section of the gear **6** in registry with the pinion **5,** thus allowing the timing mechanism to be stalled while the motor **1** continues to run unloaded. At this time, the cam follower **31** is still on the sloping portion **35** of cam **30** and is urging rotation of the camshaft assembly or timing means, such rotation being prevented by the run abutment **29** engaging the stalling surface **70.**

The compressor will normally remain in operation until the thermostat **93** is satisfied. When this occurs, the solenoid **50** is deenergized which permits the biasing spring **60** of lever **40** to rotate this lever counterclockwise, this in turn causing counterclockwise rotation of the lever **48** and outward movement of the solenoid plunger **49.** This same motion of lever **40** also caused the abutment **45** to move to the right against the driven surface **77** of the run stall lever **71.** This released the stalling surface **70** from abutment **29** on gear **6** and simultaneously released the latch **73** allowing downward movement of switch blade **11** for opening the contacts of switch **9.** This deenergized the compressor contact coil **94** which in turn deenergized the compressor **96.** Due to the stalling surface **70** being released, the starter cam follower **31** acting on sloping portion **35** caused rotation of the cam shaft assembly for bringing gear **6** back into engagement with the pinion **5.** The timing mechanism will now run back to the standby position where the parts are stalled by the standby stalling surface **43** being engaged by the standby abutment **27** on gear **6.** At this time the latch **83** is locked in unlatched position by engagement of the blade extension **16** with the drop-off portion of the latch. This holds the run stall lever in the outer position as shown where it cannot interfere with the passage of the standby abutment **28** on gear **6.** Thus if the solenoid **50** should become energized during the four minute **45** second resetting cycle of the timer, the run stall **70** will nevertheless be held clear of the standby abutment **28.**

It should be noted that when the thermostat first calls for cooling, it energizes the solenoid **50** which rotates the lever **40** clockwise for releasing the standby stop **43** from the standby abutment **28.** This allows instant rotation of the timing means or cam shaft assembly and brings the outer edge of the run abutment **28** under the lower surface of lever **40.** This temporarily locks the safety controls **91** and **92** and the thermostat **93** out of control relationship over the compressor. Even if these controls opened their circuits and deenergized the solenoid **50,** the lever **40** is maintained in its raised position so that the abutment **45** is spaced from driven surface

77 of run stall lever 71 so as to allow the latch 73 to move into place and cause closure of switch 9. The standby abutment 28 and the lower edge of lever 40 are arranged so as to require approximately 30 seconds for the abutment 28 to clear the lever 40 and place it back under the control of the condition responsive devices. 15 seconds of this 30 second interval is taken up in closing the switch 9 to start the compressor. This means that the compressor must now run at least 15 seconds irrespective of the safety controls 91 and 92. This minimum on period prevents false stopping of the compressor due to surges occuring when the compressor first starts. The condition responsive devices are locked out mechanically by the timing mechanism for sufficient time to allow the surges to settle down. These controls are then placed back into full control so that the compressor can be stopped instantly if an unfavorable condition occurs.

The purpose of the compound leverage system including levers 48 and 40 is to obtain more useful work from the solenoid and to make it operable over a wide voltage range. FIG. 3 shows a typical force-to-stroke curve for a solenoid of the type illustrated. This curve indicates the solenoid will pull approximately 10 ounces when the plunger is 0.5 inches from its seated position. As the plunger comes in, the force increases to approximately 15 ounces at 0.2 inches stroke. As the plunger continues its inward motion the force available rapidly increases having approximately 35 ounces pull when the plunger is seated.

The use of the compound lever system makes it possible to utilize a long stroke on the solenoid without excessive movement of the lever 40. Also with the camming surface 57 on lever 40 the ratio of motion of lever 40 relative to plunger travel is arranged to take advantage of the non-linear force characteristic of the solenoid. With the camming surface illustrated, initial movement of the solenoid plunger from its retracted position results in relatively small movement of the lever 40 against the action of its biasing spring 60. Thus the outward pull on the solenoid is at a minimum corresponding with the force available from the solenoid at that position. AS the solenoid plunger moves in, the slope of the camming surface contacted by the portion 50 of lever 48 increases thus increasing the movement of lever or power take-off member 40, taking advantage of the increasing pull available as the solenoid pulls in.

It should be noted that any time after abutment 28 clears the lever 40, the latch 73 can be released by deenergizing of the solenoid for opening the switch 9. Once the latch has been released and the switch opened the switch will remain open until the timer returns to the starting position where latch 73 comes back into place and the cam follower 23 rides off lobe 98 of cam 8. This insures that the compressor cannot be started too often, and that its operation will always be delayed until the pressures in the system equalize so that the compressor can start in an unloaded condition. This is very desirable except when the system is being tested either on initial installation or during a service call. Hence the manual override is provided. When it is desired to start this system manually the thermostat 93 is turned up so as to energize the solenoid 50 thus rocking lever 40 and moving the abutment 45 away from the run stall lever 71. The handle 82 on the manual lever 81 is now raised, bringing the camming surface 74 into engagement with the end of switch blade 11 thus raising this blade. This engages the contacts closing switch 9 and starting the compressor. On continued movement of the lever 82, the switch blade 11 is raised high enough to lift the cam follower 19 sufficiently to be clear of the cam at its highest portion. Continued rotation of the manual lever brings the circular portion 84 beneath the extension 16 of switch blade 11. Now there is no returning force on the manual lever and it will stay in the on position indefinitely. When the manual lever 81 is rotated counterclockwise and after the blade extension 16 has been lifted clear of the latching surface on latch 74, the latch will move into latching position under extension 16 due to the biasing spring 75. At this time due to the solenoid being energized, the abutment 45 is clear of the run stall lever which allows this movement of the latching position.

The compressor will now remain in operation until the thermostat 93 is reset or until the room temperature is reduced to the setting of the thermostat. Opening of the thermostat circuit drops out the solenoid 50 allowing counterclockwise rotation of lever 40 under the acting of biasing spring 60. The abutment 45 on lever 40 moving to the right rocks the run stall lever 70 clockwise which also causes clockwise rotation of the latch 73. In its releasing motion latch 73 engages the pin 86 on the manual override lever 81 thus causing clockwise rotation of this lever into the released position shown.

The manual override lever can also be operated without first energizing solenoid 50. In this case rotation of the lever first lifts the lower blade 11 until the extension 16 is raised above the latching surface 74 on latch 73. After this occurs the pin 86 on the override lever engages the back of the latch and rotates it into latching position against the yielding action of the abutment 45 on the run stall lever 71. In other words manual operation of the manual override lever overcomes the spring 60. However now when the manual override lever is released, the spring 60 will move latch 73 to released position which in turn moves the manual override lever to released position.

From the foregoing it will be seen that the manual override lever may be used in two different ways. In one case by turning the thermostat down to energize the solenoid, the manual lever can be released after the compressor is started and the compressor will run until the solenoid is deenergized. In the other method the manual lever can be operated without closing the thermostat circuit. However in this case the manual lever must be held in actuated position as long as operation of the compressor is required. In no event, is it possible to manually lock out the control system causing a dangerous situation if forgotten.

As numerous modifications may be made without departing from the spirit and scope of the invention it is desired to be limited only by the scope of the appended claims.

I claim:

1. In an electro-magnetically actuated device, an electro-magnet having a coil, an open magnetic path and a movable member of magnetic material arranged to move in a direction closing said path in response to energization of the coil, the magnetic force on the movable magnetic member increasing as said member moves in said direction, a power take-off member, motion transmitting means for causing movement of the

power take-off member by power provided by the movable magnetic member, means providing a normal starting position for the movable magnetic member providing a predetermined open magnetic path, means providing a normal terminal position for the movable magnetic member, said movable magnetic member being arranged normally to move from the starting position to the terminal position in response to energization of the coil, said motion transmitting means being constructed and arranged to increase the relative rate of movement of the power take-off member relative to the rate of movement of the movable magnetic member as said movable magnetic member moves from its normal starting position toward its normal terminal position, said motion transmitting means also being constructed and arranged to provide a substantially smaller relative rate of movement of the power take-off member when the movable magnetic member is at its starting position than provided as said movable member approaches its terminal position.

2. A device as specified in claim 1 in which the motion transmitting means includes a camming surface which is contacted at different points as the movable magnetic member moves from its starting position to its terminal position.

3. A device as specified in claim 2 in which the motion transmitting means comprises a first lever operated by the movable member and a second lever, said levers being pivoted at spaced points, the camming surface being associated with one of said levers.

4. A device as specified in claim 3 in which the second lever is provided with biasing means urging it against the first lever, the biasing means acting through the camming surface to urge the movable magnetic member in a direction opening the magnetic path.

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